Species

22(70), 2021

Distribution and the importance of non-viviparous and associate mangrove plant species in Coringa Mangrove Forest, Andhra Pradesh, India

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To Cite:
Suvarna Raju P, Solomon Raju AJ. Distribution and the importance of non-viviparous and associate mangrove plant species in Coringa Mangrove Forest, Andhra Pradesh, India. *Species*, 2021, 22(70), 226-232

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Peer-Review History
Received: 24 May 2021
Reviewed & Revised: 28/May/2021 to 26/July/2021
Accepted: 29 July 2021
Published: August 2021

Peer-Review Model
External peer-review was done through double-blind method.

DISCOVERY SCIENTIFIC SOCIETY

ABSTRACT

A total of twenty five non-viviparous and mangrove associate plant species have been recorded in Coringa Mangrove Forest. The distribution of these plant species across salinity gradient zones and the role of individual species in soil accretion and control of land/soil erosion from tidal waters have been documented. Further, the flowering season of each noted species and its possible association with positive water balance and high levels of dissolved oxygen has also been discussed.

Key words: Non--viviparous species, mangrove associates, Coringa Mangrove Forest.

1. INTRODUCTION

Climate change associated with global warming has been threatening terrestrial and wetland ecosystems in the entire world but its impact on mangrove ecosystems is very intense. Because climate change is contributing to a rise in sea level causing intrusion of saline water in the mangrove forest ecosystems (Haque and Reza, 2017). As a result, the fresh water flowing from rivers is being transformed into saline water and brackish water into high saline water within the estuarine or mangrove extent area (Day et al. 1995; Barlow, 2003). The Coringa mangrove forest ecosystem in Andhra Pradesh, India is vulnerable to water and soil salinity because it modifies the salinity gradient of salinity distribution and flooding level on the mangrove forest floor.

Upadhyay et al. (2002) reported that nearly half of the mangrove forest cover has been destroyed worldwide. Land use changes and multiple uses of mangroves have contributed to the present state of mangrove cover. The Coringa mangrove forest ecosystem has been threatened by deforestation activity due to tree felling for fuel wood and use of oligohaline areas as open cattle sheds by fishermen community. This forest ecosystem is an abode for viviparous and non-viviparous species and also for mangrove associate

species as it is located abutting the confluence point of the Godavari river and the sea of Bay of Bengal. The fresh water that flows from the Godavari river has 0.5 ppt or less salinity level. Within this mangrove forest, salinity gradient is maintained from landward to seaward and the salinity levels vary from 0.5 to 5 ppt (oligohaline), 5-18 ppt (mesohaline) and 18-30 ppt (polyhaline) (Rama Mohan, 2009).

Mangrove flora represents two groups according to the habitat type within the estuarine zone, true mangroves and mangrove associates, the former indicate the species that grow well in intertidal zones while the latter indicate the species that grow well both in littoral and terrestrial habitats. Both groups collectively constitute highly productive components of the food web of coastal ecosystem in general and estuarine ecosystem in particular as they are efficient in carbon sequestration. Mangrove rhizosphere zone is the home for estuarine and certain marine fauna. The root network is very important to protect nearby high lands from damage and erosion. Further, they assimilate pollutants and recycle nutrients through various biochemical processes (Upadhyay et al. 2002). In the last three decades, the Coringa mangrove forest has been facing tremendous threats due to indiscriminate and irrational exploitation of its resources by local fishermen community and land use changes for aquaculture development and conversion to agricultural/residential/commercial activities. In this process, the mangrove species composition and the population dynamics have been affected to a greater extent. Keeping this situation in view, a study has been made to list out the true mangrove species and mangrove associates that grow well along the landward side of the forest and brackish water creeks and their role in the stabilization of mangrove forest floor towards land and along the banks of creeks. The findings have been discussed in the light of relevant works.

2. MATERIALS AND METHODS

The Coringa Mangrove Forest (16°30′–17°00′N and 82°10′-80°23′E) in the Godavari deltaic region of East Godavari district, Andhra Pradesh, India (Figure 1a-d, 2a-d), was used as the study site during May 2019-March 2020 to carry out a field survey to record the distribution pattern of non-viviparous and mangrove associate plant species across different salinity gradients from land ward to seaward side. The salinity zone where individual species is distributed and the role of individual species in soil accretion and in controlling land/soil erosion from tidal waters have been recorded. The activities of local fishermen in this wetland system have also been noted.

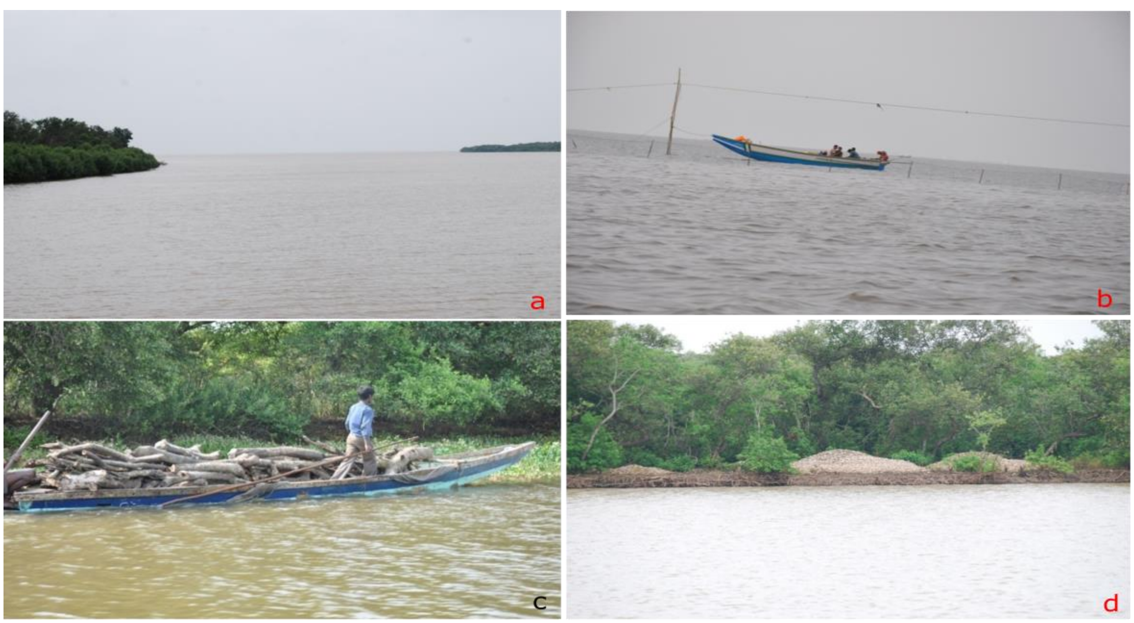

Figure 1. Mangrove forest: a. Mangrove forest along Godavari-Bay of Bengal line, b. Godavari river mouth point, c. Cut tree logs transported in a small boat by fishermen, d. Piles of shells gathered by fishermen for lime making.

ISSN 2319–5746 EISSN 2319–5754 I OPEN ACCESS

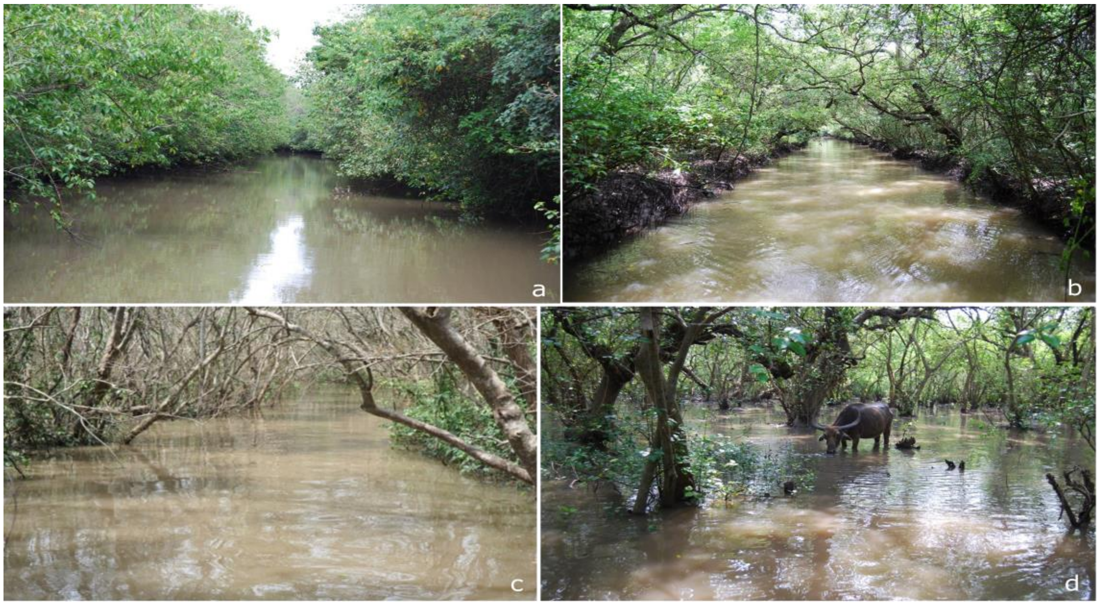

Figure 2. Mangrove forest: a-d. Mangrove creeks – a. Entry point of narrow creek, b. Inside narrow creek during rainy season, c. Inside narrow creek during summer season, d. Creek area during the period of tidal water receding back to sea.

3. RESULTS AND DISCUSSION

A total of twenty five non-viviparous true mangrove and mangrove associate plant species has been recorded from the Coringa Mangrove Forest (Table 1). The non-viviparous plant species include *Lumnitzera racemosa* (Figure 4a), *Excoecaria agallocha, Barringtonia racemosa* (Figure 5a), *Xylocarpus granatum* (Figure 5f), *X. mekongensis* (Figure 6a), *Scyphiphora hydrophyllacea* (Figure 6d), *Sonneratia alba* (Figure 7a) and *S. apetala* (Figure 7b). Of these, *B. racemosa* is reported to be a true oviparous species by some workers and as a mangrove associate by some other workers in the literature. In this study, this species is considered to be a mangrove associate since it grows also in non-estuarine habitats. The species, L. *racemosa, E. agallocha, B. racemosa, X. mekongensis* grow in oligohaline to mesohaline zones. *S. hydrophyllacea* and *S. apetala* grow in mesohaline zone, *X. granatum* in polyhaline to euhaline zones, and *S. alba* in euhaline zone. All these plant species are wet season bloomers as they bloom during June-August period. However, *B. racemosa, X. granatum, X. mekongensis, S. hydrophyllacea, S. alba* and *S. apetala* also bloom sporadically throughout the year.

Table 1. List of true oviparous and mangrove associate plant species of Coringa Mangrove Forest

Family	Plant species	Salinity gradient zone	Flowering season
Acanthaceae	*Acanthus ilicifolius*	Oligohaline to Mesohaline	April-November
Apocynaceae	*Sarcolobus carinatus*	Oligohaline	July-August
Caesalpiniaceae	*Caesalpinia crista*	Oligohaline	August-October
Chenopodiaceae	*Suaeda maritima*	Oligohaline	July-October
	Suaeda monoica	Oligohaline	July-October
	Suaeda nudiflora	Oligohaline	Year-long Peak: July-September
Combretaceae	*Lumnitzera racemosa*	Oligohaline to Mesohaline	July-August
Convolvulaceae	*Ipomoea tuba*	Oligohaline	August-September
Cucurbitaceae	*Mukia maderaspatana*	Oligohaline	July-October
Euphorbiaceae	*Excoecaria agallocha*	Oligohaline to Mesohaline	June-August
Fabaceae	*Dalbergia spinosa*	Oligohaline	February-April
	Derris trifoliata	Oligohaline to Mesohaline	July-August
Lecythidaceae	*Barringtonia racemosa*	Oligohaline to Mesohaline	Year-long
Malvaceae	*Brownlowia tersa*	Oligohaline to Mesohaline	July-September
	Hibiscus tiliaceus	Oligohaline	October-January
	Malachra capitata	Oligohaline	September-October

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	Thespesia populnea	Oligohaline	November-March
Meliaceae	*Xylocarpus granatum*	Polyhaline to Euhaline	June-August Sporadic: Year-long
	Xylocarpus mekongensis	Oligohaline to Mesohaline	June-August Sporadic: Year-long
Poaceae	*Myriostachya wightiana*	Oligohaline	August-November
	Saccharum spontaneum	Oligohaline	September-November
Rubiaceae	*Scyphiphora hydrophyllacea*	Mesohaline	Year-long Peak: June-August
Sonneratiaceae	*Sonneratia alba*	Euhaline	August
	Sonneratia apetala	Mesohaline	May-August
Typhaceae	*Typha domingensis*	Oligohaline	Year-long

The mangrove associates include *Acanthus ilicifolius* (Figure 3a), *Sarcolobus carinatus* (Figure 3b), *Caesalpinia crista* (Figure 3c), *Suaeda maritima* (Figure 3d), *S. monoica* (Figure 3e), *S. nudiflora* (Figure 3f), *Ipomoea tuba* (Figure 4b), *Mukia maderaspatana* (Figure 4c), *Dalbergia spinosa* (Figure 4e), *Derris trifoliata* (Figure 4f), *Brownlowia tersa* (Figure 5b), *Hibiscus tiliaceus* (Figure 5c), *Malachra capitata* (Figure 5d), *Thespesia populnea* (Figure 5e), *Myriostachya wightiana* (Figure 6b), *Saccharum spontaneum* (Figure 6c) and *Typha domingensis* (Figure 7c). Of these, only *H. tiliaceus* and *T. populnea* are tree species while all others represent either shrub or herb or climber habit. According to the salinity gradient factor, *A. ilicifolius*, *D. trifoliata* and *B. tersa* are oligohaline and mesohaline species while all others are oligohaline species. Among these species, *D. spinosa* blooms during dry season, *A. ilicifolius* during dry and wet season, *H. tiliaceus* during latest wet and winter season and *T. populnea* during winter and early dry season. *T. domingensis* is a year-long bloomer. All other mangrove associate species are characteristically wet season bloomers.

Blasco (1977) and Haque and Reza (2017) reported on species distribution in Sundarbans Mangrove Forests. These authors noted that *Acanthus officinalis* is a predominating under-shrub in small open patches. *Caesalpinia crista* and *Dalbergia spinosa* thrive well and form impenetrable populations in the riverine patches. *Sonneratia* species occur in the shoreline and survive well on loose substratum but *S. apetala* individuals increase in frequency towards the ocean side. *Hibiscus tiliaceus* is a species of drier areas where water level is low and not inundated. *Brownlowia tersa* grows in small creeks. Azariah et al. (1992) reported that *Suaeda maritima* grows abundantly in flat clay soils while *Myriostachya wightiana* and *Acanthus ilicifolius* colonize the banks of channels in areas of high elevation devoid of inundation of tidal sea water during the high tidal period in Coringa mangrove forest. In the present study, *A. ilicifolius* is abundant in the landward side but it is gradually invading towards mesohaline zones where tree felling is quite prominent indicating that it is tolerant to high salinity levels in mesohaline zone. *C. crista* and *D. spinosa* being oligohaline species are restricted to landward side of the forest despite land use changes in the area. *Sonneratia alba* is exclusively a euhaline and seaward species while *S. apetala* is a mesohaline species indicating that these allied species occupy different habitat preferences with different salinity levels. *H. tiliaceus* is clearly an oligohaline species and distributed on the landward side with dry conditions indicating that it is a species useful in eco-restoration programs intended for land restoration in fringe areas of mangrove forest as well as in beach restoration due to its ability to act as an effective sand or soil binder. All non-viviparous species except *E. agallocha* represent a few individuals with scattered distribution in the respective salinity gradient zones and contribute to the formation and stabilization of forest floor in those zones. *E. agallocha* has considerable size of population distributed continually in rows and also in scattered form. This species although important for forest floor stabilization, it is gradually invading into the open gaps and cleared areas due to tree felling. *S. hydrophyllacea* is a rare species distributed in specific area representing mesohaline zone but this species appears to be resorting to vegetative reproduction as there is no recruiting from seeds because the latter do not have the ability to germinate and produce new plants (Solomon Raju and Rajesh, 2014). In the area where it is distributed, it nearly formed a huge population intermingled with a few scattered individuals of other true mangrove species. In case of mangrove associates, *T. populnea* grows only in landward areas characterized by dry to semi-dry soil conditions and acts as an effective sand and/or clay binder contributing to soil accretion. *S. carinatus, D. spinosa, D. trifoliata* and *B. tersa* with huge populations distributed along the banks of small creeks have an important role in soil building and stabilization forming lining to both sides of the creeks. All other mangrove associate species with huge populations by restricting their distribution to landside enable land building which prevents soil erosion due to inward and outward tidal water flows.

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Figure 3. a. *Acanthus ilicifolius*, b. *Sarcolobus carinatus*, c. *Caesalpinia crista*, d. *Suaeda maritima*, e. **S***uaeda monoica*, f. *Suaeda nudiflora*.

Figure 4. a. *Lumnitzera racemosa,* b. *Ipomoea tuba*, c. *Mukia maderaspatana*, d. *Excoecaria agallocha*, e. *Dalbergia spinosa*, f. *Derris trifoliata*.

Figure 5. a. *Barringtonia racemosa*, b. *Brownlowia tersa*, c. *Hibiscus tiliaceus*, d. *Malachra capitata*, e. *Thespesia populnea*, f. *Xylocarpus granatum*.

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Figure 6. a. *Xylocarpus mekongensis, b. Myriostachya wightiana, c. Saccharum spontaneum, d. Scyphiphora hydrophyllacea.*

Figure 7. a. *Sonneratia alba,* b. *Sonneratia apetala,* c. *Typha domingensis*

Montagna et al. (2013) reported that the salinity in estuaries varies according to the levels of freshwater inflows as well as the tidal movement and location within the estuaries. In general, estuaries exhibit positive or neutral or negative water balance. Positive water balance is characterized by freshwater inputs exceeding evaporation, neutral water balance by a balance between freshwater inflows and evaporation, and negative water balance by freshwater inflows less than the amount of evaporation. In Coringa Mangrove forest, estuarine body displays a decrease in salinity during wet season with increased inflows leading to a positive water balance and an increase in salinity during summer season with decreased or no freshwater inflows and increased evaporation due to higher temperatures leading to a negative water balance. Salinity affects the chemical conditions in the estuarine body, most notably the amount of dissolved oxygen. Solubility of oxygen levels in water decreases with an increase in salinity. In this study, almost all plant species have been found to be flowering typically during wet season although a few plant species also bloom sporadically throughout the year. The wet season flowering in these plant species is an indication that positive water balance and more dissolved oxygen in water are essential for the occurrence of flowering. In recent years, insufficient, erratic and even failure of monsoon rains are contributing to reduced fresh water levels in rivers and inflows into estuaries, in the present case, Coringa estuarine water body. This situation if prevails continuously, the annual phenological events, leaf fall, leaf flushing, flowering and fruiting will be affected and accordingly the structural and functional aspects of the mangrove forest together with species composition, survival and abundance will be modified. Therefore, the study concludes that the distribution pattern of non-

ISSN 2319–5746 EISSN 2319–5754 I OPEN ACCESS

viviparous and mangrove associate species and their population status have an important role in the conservation and management of forest floor and in lining both sides of small creeks for the natural inflow and outflow of tidal water.

4. CONCLUSION

Coringa Mangrove Forest is a precious coastal wetland ecosystem that supports true viviparous, crypto-viviparous and non-viviparous species, and also mangrove associate species due to the presence of different salinity gradient zones. The non-viviparous and mangrove associate species play an important role in soil accretion and control land/soil erosion from tidal waters. The flowering of these species, in principle, during wet season is an indication of the requirement of positive water balance with more dissolved oxygen in water. Rise in global temperature and increased carbon dioxide concentrations in the atmosphere could increase productivity in mangrove forests, bring about change in the timings of flowering and fruiting events, and distribution pattern of plant species across salinity gradient zones. Fishermen living along forest fringes depend on this forest cover for livelihood as they use twigs and woods for fire and boat/furniture making. They also use certain pockets of the forest towards landside as cattle sheds. These human activities need to be regulated by strict implementation of the existing Forest Acts in order to ensure the self-restoration by the constituent species for the structural and functional integrity of the entire wetland ecosystem.

Acknowledgement

We thank the Andhra University, Visakhapatnam, for providing all physical facilities to carry out this research work.

Authors contributions

Both authors contributed equally.

Ethical approval

The ethical guidelines for plants & plant materials are followed in the study for species collection & identification.

Funding:

This research received no external funding.

Conflicts of interest:

The authors declare no conflict of interest.

Data and materials availability

All data associated with this study are present in the paper.

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ISSN 2319–5746 EISSN 2319–5754 I OPEN ACCESS